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PATENT APPLICATION

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | | |
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| In re Application of | : | Jeremy John GREENWOOD, Kevin Trevor TALBOT and Christopher Richard BOTTOMLEY |
| Serial no. | : | 09/954,765 |
| Filed | : | September 18, 2001 |
| For | : | A SECURITY SYSTEM |
| Group Art Unit | : | |
| Examiner | : | |
| Docket | : | LANDRO P148US |

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The Commissioner of Patents and Trademarks
Washington, D.C. 20231

## SUBMISSION OF CERTIFIED COPIES

Dear Sir:

A claim for priority is hereby made under the provisions of 35 U.S.C. § 119 for the above-identified United States Patent Application based upon British Patent Application Nos. 0022940.1 and 0105160.6, filed September 19, 2000 and March 2, 2001, respectively. A certified copy of each British application is enclosed herewith.

In the event that there are any fee deficiencies or additional fees are payable, please charge the same or credit any overpayment to our Deposit Account (Account No. 04-0213).

Respectfully submitted,

Michael J. Bujold

Michael J. Bujold, Reg. No. 32,018
**Customer No. 020210**
Davis & Bujold, P.L.L.C.
Fourth Floor
500 North Commercial Street
Manchester NH 03101-1151
Telephone 603-624-9220
Facsimile 603-624-9229
E-mail: patent@davisandbujold.com

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## CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service, with sufficient postage, as First Class Mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231 on October 24, 2001.

By: Michael J. Bujold
Print Name: Michael J. Bujold

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

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Dated 20th September 2001

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19SEP00 E569455-1 D01520
P01/7700 0.00-0022940.1

# Request for grant of a patent

**The Patent Office**

**Cardiff Road**
**Newport**
**Gwent NP10 8QQ**

| | | |
|---|---|---|
| 1. Your reference | 200-1369 | |
| 2. Patent application number | 19 SEP 2000 | **0022940.1** |
| 3. Full name, address and postcode of the or of each applicant. | Land Rover Group Limited<br>26 New Street<br>St Helier<br>Jersey | |
| Patents ADP number | 04911833001 | |
| If the applicant is a corporate body, give the country/state of its incorporation | Jersey | |
| 4. Title of the invention | **A Security System** | |
| 5. Name of your agent | O. R. T. Davies et al | |
| "Address for service" in the United Kingdom to which all correspondence should be sent. | Land Rover Group Limited<br>Patent Department<br>Gaydon Test Centre<br>Banbury Road, Lighthorne<br>Warwick CV35 0RG | |
| Patents ADP Number | 04659801001 | |

| 6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or each of these earlier applications and the or each application number. | Country | Priority application number | Date of filing |
|---|---|---|---|
| | - | - | - |
| | - | - | - |
| | - | - | - |

| 7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application | Number of earlier application | Date of filing |
|---|---|---|
| | | - |

| | |
|---|---|
| 8. Is a statement of inventorship and of right to grant of a patent required in support of this request. | YES |

**Patents Form 1/77**

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

| | |
|---|---|
| Continuation sheets of this form | |
| Description | 5 ✓ (see second page) |
| Claim(s) | 1 ✓ |
| Abstract | |
| Drawing(s) | 1 ✓ |

10. If you are also filing any of the following, state how many against each item.

| | |
|---|---|
| Priority documents | |
| Translations of priority documents | |
| Statement of inventorship and right to grant of a patent *(Patents Form 7/77)* | |
| Request for preliminary examination and search *(Patents Form 9/77)* | |
| Request for substantive examination *(Patents Form 10/77)* | |
| Any other documents *(please specify)* | |

11. I/We request the grant of a patent on the basis of this application.

Signature

O. R. T. Davies Agent

Date
19 September 2000

12. Name and daytime telephone number of person to contact in the United Kingdom.

O. R. T. Davies 01926 643458

# A Security System

This invention relates to security systems, and in particular to a security system arranged in use to facilitate passive access to and/or use of a protected object or area such as a vehicle.

When fitted to a vehicle, a "Passive entry and passive go" security system allows a user to :
Gain entry to the vehicle by operating for example a door handle; and to
Remobilise the vehicle to facilitate for example starting.
The user can achieve this merely by having a transponder about their person, i.e. without inserting or operating a key.

A system of this kind might operate by sending a challenge to a transponder using a low frequency signal (e.g. 125 kHz). The transponder would then reply with an encryption of the challenge on a higher frequency (e.g. 434MHz). The challenge is sent on the operation of e.g. the door handle. The low frequency signal may be sent from coils located near the front doors and boot. Further coils may be installed in the interior of the vehicle in an attempt to determine when the transponder is inside the vehicle to allow e.g. engine starting.

It is a problem with some prior art security systems that a criminal can interpose transmitter-receiver pairs with a 2-way link between the vehicle and the owner. The criminal might succed in gaining access to the car, although the authorising transponder is not locally present. It is possible that no knowledge of the system encryption may be required. Some protection against this is provided by requiring the equipment to be sophisticated and any attempted rely hacker to be skilled and knowledgeable/observant. One system which offers protection against a relay hacker is disclosed in GB 2332548 and its contents are hereby included in the disclosure of this application.

It is an objetct of this invention to provide an improved security system.

The invention will now be described with reference to the accompanying drawings.

In one known system, the transponder requires three orthogonal coils to guarantee reception of the signal from the car. In this invention, the signals from the three transponder coils are processed so that the transponder is able to determine the vector of the incoming signal from each of the three vehicle coils, A, B and C. This information is sent back in the encrypted response. The system requires that the angular separation between the vectors falls within predetermined limits set by the geometry of the vehicle.
To reproduce the signals, a hacker would have to employ additional apparatus and would have to place them in specific locations with respect to the target. The hacker would also have to deduce the operation of the system, which is difficult as it uses a hardware configuration similar to a standard system but with the operation buried in the signal processing and encrypted data.
The base station (car) 10 sends the challenge or challenges sequentially on two or more of the base station coils. The signal from each is identified with it's location, A, B, or C. Note that the probable location of the transponder is known to the car 10 as the operation is, typically, initiated by the operation of a user operated control means

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such as for example a door handle 20 or a starter switch 30. The transponder contains three substantially orthogonal coils, X, Y & Z. These are connected via analogue switches to a single LF receiver (or to three LF receivers without analogue switches.) The level of the signal in each coil, X, Y & Z, is measured and the values encrypted and returned with the response from the transponder. [1]
Note that the level may be a negative value. This is not absolute and it is assumed that one of the directions, e.g. x, is defined as positive and the others are positive or negative depending on the sense of the signal
It is likely that the message format will be a challenge response with an authentication function as well as the levels x, y & z, i.e.:

Challenge:- Ident. Challenge
Response:- Encrypted [Ident. challenge x y z]

Clearly, the encryption must be a symmetrical algorithm and the encryption key(s) stored in both the transponder and controller.

The response from the transponder will generally be an RF signal similar to the remote locking communication. The controller receives and decrypts this response. The decrypted response is checked to ensure that the challenge matches with the transmitted challenge. This authenticates the key in the conventional fashion.

The decrypted signals x, y & z are related to the direction of reception due to the approximate cosine relation between coil orientation and incident vector. [2]
Therefore, the controller ECU on the vehicle can now derive this 3D vector from the relative amplitudes x, y and z of the signals in the coils. The angle of the vector from transmission A can be expressed as:

$$\phi_A = f(x_A, y_A, z_A), \text{ similarly for B and C}$$

The angular differences between the vectors for the transmissions from each of the vehicle coils A, B, C.... are then derived:-

$$\phi_{AB} = \phi_A - \phi_B;$$
$$\phi_{BC} = \phi_B - \phi_C;$$
$$\phi_{AC} = \phi_A - \phi_C$$

The basestation will only allow entry or remobilisation if the encrypted response is correct and the angles meet criteria related to the geography of the vehicle.
For an application with three vehicle coils, A, B, C located in the exterior mirrors and at the rear window;

[1] Note that the vector could be pre-calculated in the transponder and the result transmitted back. However, it is easier to make this calculation in the vehicle ECU as it is typically faster due to the power supply availability.
[2] Note that this direction is defined in a frame of reference containing the transponder. As the transponder may be at any orientation, this vector has no defined relationship to the vehicle.

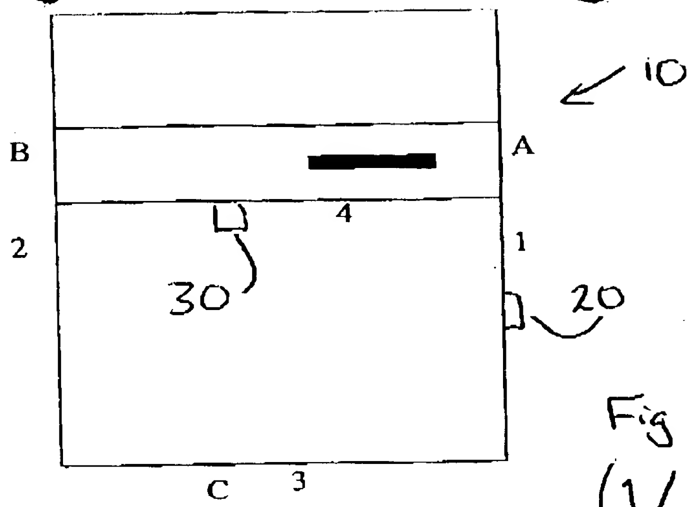


Fig 1 (1/2)

| | |
|---|---|
| For entry from the RHF door, 1, | $270° > \phi_{AC} > 90°$ |
| For entry from the LHF door, 2, | $270° > \phi_{CB} > 90°$ |
| For entry from the boot, 3, | $90° > \phi_{AB} > 30°$ |
| For remobilisation from the drivers seat, 4, | $210° > \phi_{AB} > 150°$ |

(Angles defined by geography of vehicle – these are "typical" values)

In practice, more vehicle coils may be used to reduce the range required from each coil.

## *Relative Phase*

Note that for any given set of signals received in X, Y and Z, there are two possible solutions for the vector, diametrically opposite. To resolve this issue, it is necessary to retain the phase information when measuring the first direction, $\phi_A$ and to solve $\phi_B$ with the same phase reference. When $\phi_{AB}$ is calculated, the relative phase is known and the value for $\phi_{AB}$ can be determined.

## *Absolute Location*

Note that for a passive start application, it is required that the transponder, and hence the driver, is in the car, not adjacent to it before allowing the car to be started. "Conventional" passive systems utilise the limited range of specifically located interior LF coils to determine this. This is not reliable, as the range of system components will vary, as will the presence of metal objects and other distorting factors. Use of the three orthogonal coils X, Y, Z provides substantially absolute confirmation of the location of the transponder inside the vehicle.

## *Self Calibration*

Two requirements for the coils X, Y, Z may create problems:

- In the interests of sensitivity, the Q of the receiver coils will be high. This will lead to variations in signal response.

- To produce a flat "credit card" transponder, one of the coils may need to be a low profile type, also leading to a varying sensitivity.

This may lead to a requirement for a self-calibration function. This is achieved by adding a fourth coil equally spaced in angle between the other three and can be used to inject a signal into the three receiver coils and allow them to be calibrated. This calibration can be either:
Used to pre-process the signals x, y & z before transmission from the transponder or
Transmitted in the encrypted response and used by the controller to normalise the signals.

### *Mechanical Implementation*

The coil assembly may be embeded in a plastic or epoxy material with the silicon. This is to exclude casual inspection or monitoring of the signals by a hacker.

## Further Enhancements

### *Frequencies*

The embodiment described so far relates to a system where the vehicle transmits at a nominal 125kHz and the key responds at 434MHz. Clearly, the related 315, 868 and 900 etc bands can be used.
It may be desirable to use other frequencies for the communication from the vehicle. For example, the use of 13.56MHz would allow a lower power transmission and a greater range. The coils X, Y, Z structure could be changed in scale and perhaps, structure, to accommodate the change.
Equally, the use of 434MHz in both directions may allow for some cost reduction in the transponder due to the communisation of the frequencies.

### *Hall Effect*

Hall effect sensors could be used instead of coils.

If using a hall effect sensor for direction measurement, then data can also be sent without a carrier frequency.[3]

### *Field Rotation*

It is possible to introduce a further degree of difficulty into a hacker's task by rotating the field direction from the vehicle coils. If, for example, two orthogonal coils were placed at a given location, the field vector received by the transponder would vary depending on which coil is activated. This additional information can be returned to the vehicle and used as additional validation of direct communication with the transponder.

Alternatively, the field direction can be modified in a pre-determined manner on a bit by bit basis as a code modulation. The transponder will only respond to a correct code in this modulation.

LAND ROVER GROUP ref. 200-1369



CLAIMS

1. A security system comprising a plurality of signal transmitting means spaced around a protected area and a transponder arranged in use to receive signals from the transmitting means, wherein the transponder is arranged in use to determine, from signals transmitted by a plurality of the transmitting means, vector information relating to the relative position with respect to the transponder of the transmitting means.

2. A security system according to Claim 1, wherein the vector information comprises the vector of the incoming signal from one or more signals from the transmitting means.

3. A security system according to Claim 1 or Claim 2, wherein, for detection by the transponder of said signals, the angular separation in the region of the transponder between the vectors of the transmitted signals falls within substantially predetermined limits.

4. A security system according to Claim 3, wherein said limits are set by the geometry of the protected area.

5. A security system according to any preceding Claim, wherein the transmitting means comprise a series of substantially orthogonally spaced coils.

6. A security system according to Claim 5, wherein said series comprises three coils.

7. A security system according to any preceding Claim, wherein the transponder sends the vector information back to the protected area in a response signal.

8. A security system according to Claim 7, wherein the response signal includes information related to the signal strength from the transmitting means.

9. A security system according to Claim 7 or Claim 8, wherein the protected area will allow entry and/or use only if said vector information meets predetermined criteria related to the position of the protected area with respect to the transponder.

10. A security system substantially as described herein with reference to he accompanying drawings.

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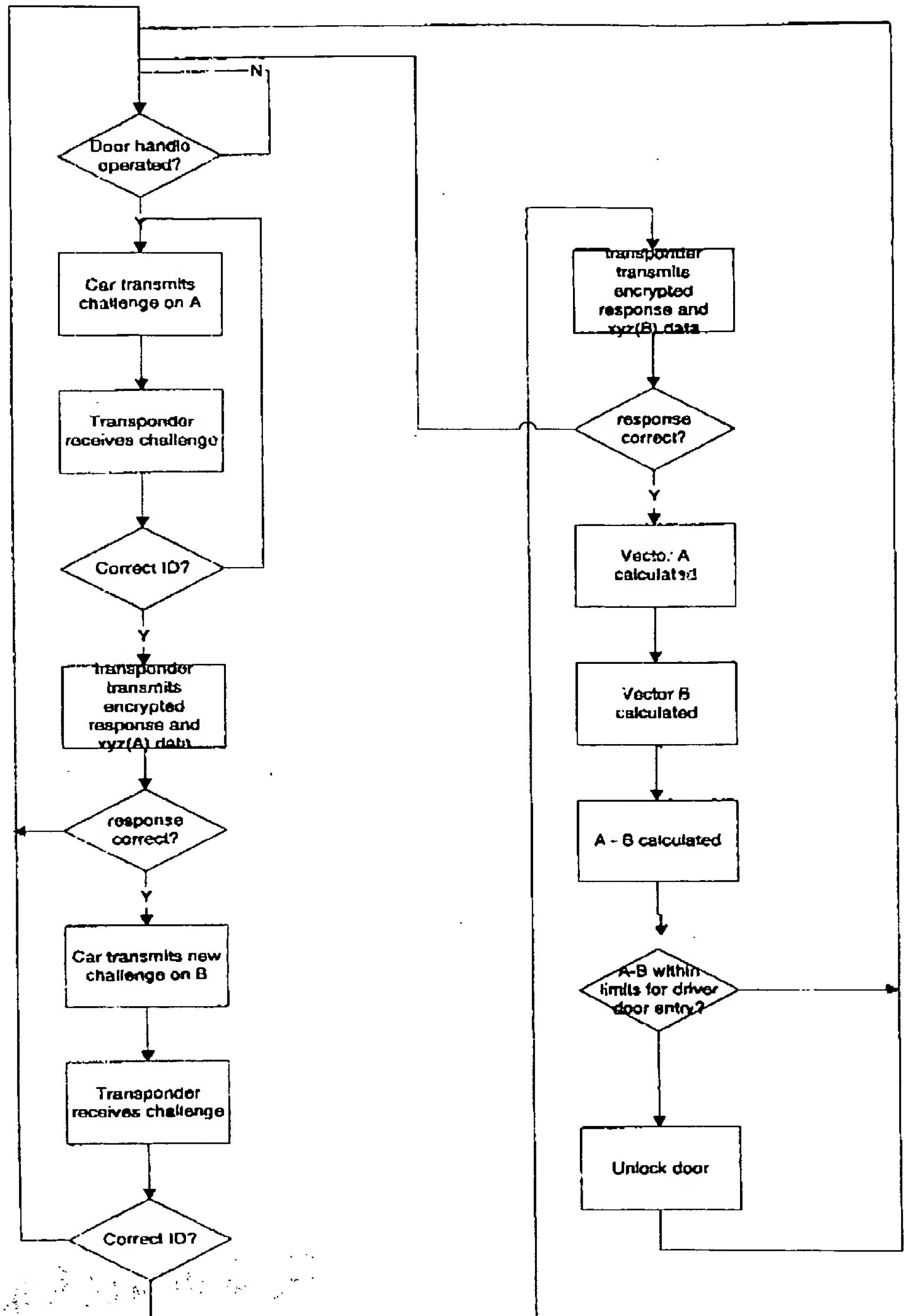


Typical Response To Operation from Door.

Fig 2

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